Space Technology Research Grants

# Nanoporous Cyclic Brush Polymers for Selective Carbon Dioxide Capture

Completed Technology Project (2015 - 2019)

## Project Introduction

The objective of the proposed work is to develop advanced synthetic methodologies that afford nanoporous materials with selective uptake affinity towards carbon dioxide and large gas storage capacities. The expected significance of this work is the increase in porosity and uptake capacity in azo-linked porous organic polymers (ALP) for carbon dioxide capture as well as increased thermal stability of these materials by the incorporation of a cyclic backbone. Cyclic polymers show remarkably different behaviors than their linear counterparts, and are expected to provide a highly tunable system for removing impurities such as carbon dioxide from breathing air aboard space vessels. The tunability will be further enhanced by the construction of ALP-based molecular brush polymers, which behave significantly differently from linear polymer analogs, and will allow for pre-established molecular design parameterization facilitated by the covalent connectivity combined with solution- and solid-state assembly processes. Cyclic brush polymers will be achieved by ring-expansion metathesis polymerization (REMP), and a significant effort will be directed towards modifications of the catalyst and reaction conditions to improve control of this polymerization. Highly dense networks of azo-linkages, recently shown to be efficacious for selective carbon dioxide uptake, will be achieved by □grafting from□ techniques. A library of cyclic brushes with varying backbone length, azo-linkage compositional fraction, and azo-linkage branch points will be prepared and tested to experimentally obtain carbon dioxide uptake capacity and selectivity. The preparation and subsequent testing of these materials will involve a wide array of synthetic and characterization techniques. For polymers soluble in organic solvents, solution-state NMR spectroscopy will be used to obtain their compositions and number-average molecular weight values; size exclusion chromatography (SEC) will be used to obtain their molecular weights and molecular weight distributions. Differential scanning calorimetry (DSC) and thermogravimetric analysis will probe the glass and melting transition temperatures and the thermal stability, respectively. Atomic force microscopy (AFM) and scanning electron microscopy (SEM) will be used to image the surface characteristics of these materials. The porosity, carbon dioxide uptake capacity, and carbon dioxide selectivity will be determined experimentally with physisorption analysis. It is expected that the proposed work will afford a simple, scalable synthesis of a cyclic brush polymer system with highly tunable porosity and surface morphology that can be utilized for selective capture of carbon dioxide. The proposed project is also expected to yield a better fundamental understanding of the physicochemical behaviors and functionalization potential of these systems with regard to their applications in space technology as lightweight, nanoporous materials.

## Anticipated Benefits

The expected significance of this work is the increase in porosity and uptake capacity in azo-linked porous organic polymers (ALP) for carbon dioxide


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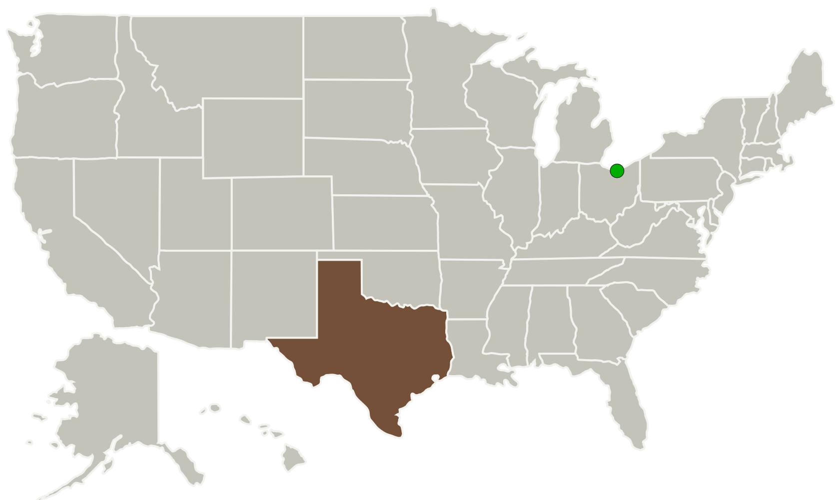
## Table of Contents

capture as well as increased thermal stability of these materials by the incorporation of a cyclic backbone. It is expected that the work will afford a simple, scalable synthesis of a cyclic brush polymer system with highly tunable porosity and surface morphology that can be utilized for selective capture of carbon dioxide. The project is also expected to yield a better fundamental understanding of the physicochemical behaviors and functionalization potential of these systems with regard to their applications in space technology as lightweight, nanoporous materials.

### Primary U.S. Work Locations and Key Partners



| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| Texas A & M University-College Station(Texas A&M) | Lead Organization | Academia Hispanic Serving Institutions (HSI) | College Station, Texas |
| Glenn Research Center(GRC) | Supporting Organization | NASA Center | Cleveland, Ohio |

| Primary U.S. Work Locations |
|---|
| Texas |

## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Organization:**

Texas A & M University-College Station (Texas A&M)

**Responsible Program:**

Space Technology Research Grants

## Project Management

**Program Director:**

Claudia M Meyer

**Program Manager:**

Hung D Nguyen

**Principal Investigator:**

Karen Wooley

**Co-Investigator:**

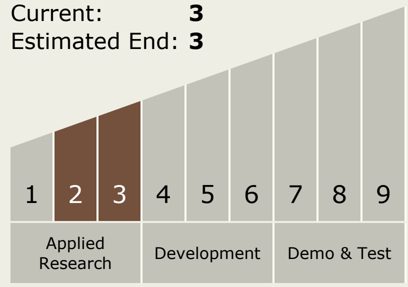
Eric Leonhardt

**Project Website:**

https://www.nasa.gov/strg#.VQb6T0jJzyE

## Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**




## Technology Areas

**Primary:**

- TX06 Human Health, Life Support, and Habitation Systems
  - └─ TX06.1 Environmental Control & Life Support Systems (ECLSS) and Habitation Systems
    - └─ TX06.1.1 Atmosphere Revitalization

## Target Destinations

Earth, The Moon